Modelling of air quality for paintings in microclimate frames

and

Experiences of the Norwegian Institute for Air Research (NILU) in providing "Air Quality Services for Cultural Heritage Professionals"

Indoor Air Quality, IAQ 2010

Chalon-sur-Saône, 22nd April 2010

SIXTH FRAMEWORK PROGRAMME

PROPAINT

Improved Protection of Paintings during Exhibition, Storage and Transit

NILU

SIXTH FRAMEWORK PROGRAMME

PROPAINT

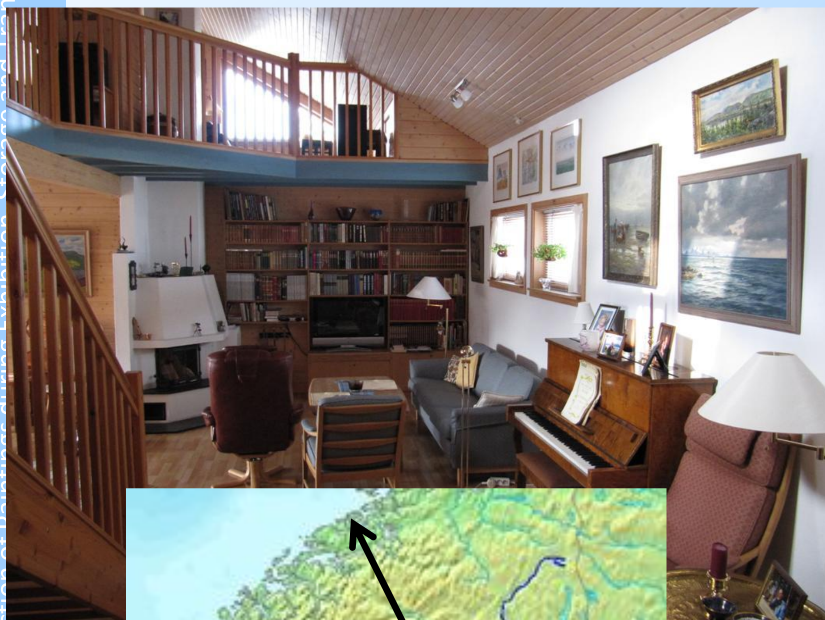
Improved Protection of Paintings during Exhibition, Storage and Transit

Contents

1. Measurements and **modelling** of gaseous pollutants in microclimate frames for paintings.
2. The protection effect of a range of microclimate frames for paintings.
3. **NILU - Services for Cultural Heritage Professionals**

NILU

Painting degradation
Worst case?



- Painted about 1935
- Moved to ”worse” climate in 1995

⇩

New damage appeared

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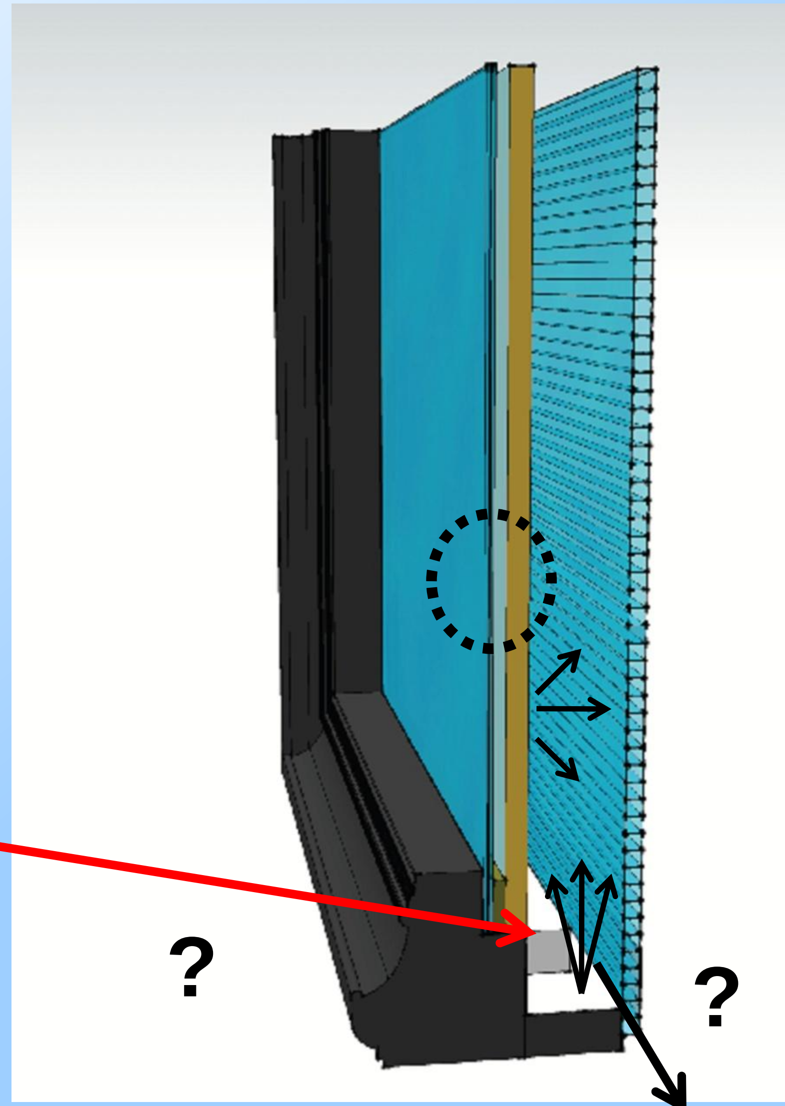
Gaseous pollutants in mc-frames

Infiltration from outside (outdoor – room):

NO_2, O_3, SO_2, H_2S etc.



Inside emission:

<u>VOCs:</u>
Acetic acid
Formic acid
Formaldehyde

H_2S
etc.

National Musuem of Krakow mc-frame

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”Impact pollutant flux” to painting

$$F_o(ox+ac) = F_o(NO_2+O_3) + F_o(Form.ac + Ac.ac) : C_{T1}/C_{T2}$$

Infiltrating **Mainly emitted inside mc-frame**

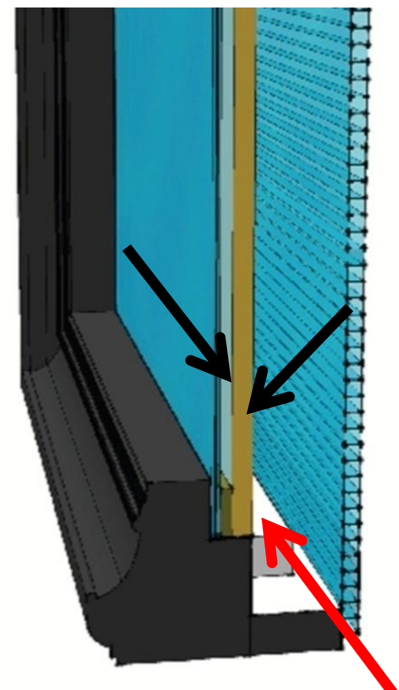
Recomended levels

C_{T1} (NO_2 + O_3) = 2 µg m^{-3}

C_{T2} (Acetic + formic acid)= 100 µg m^{-3}

$$F = v_d \text{ x } C(\lambda)$$

$$\overline{C}_i = \frac{\lambda f V C_0}{\lambda V + v_{do} A_o + v_{df} A_f} + \frac{e A_e + HV}{\lambda V + v_{do} A_o + v_{df} A_f}$$



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Procedure

Measurements:

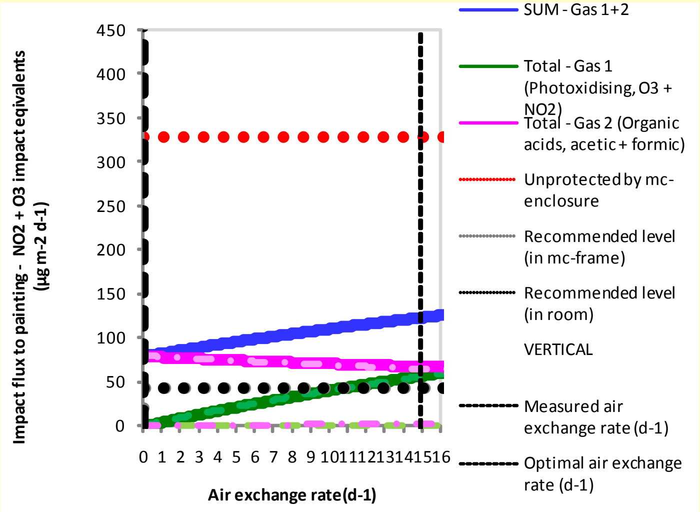
- **Ventilation rate** (air exchange) (CO_2 method)
- Inside and outside **concentrations** (Passive diff. samplers)
- Mc-frame geometry (**Volume**, Internal frame and object **area**)

Calculation:

- **Impact fluxes to the painting**
- Inside frame emisson rates
- Inside depositon velocity

MICRO-CLIMATE FRAME POLLUTION EVALUATION

Excel model



Recomended levels(µg m-3)	
$NO_2 + O_3$	2
Acetic + formic acid	100
INPUT	
Frame geometry	**Mc-frame and environmental data**
Volume (m^3)	0.315
Internal mc-frame area (m^2)	1.475
Object area (m^2)	0.625
Air exchange rate (d^{-1})	14.900
Pollutant gas 1 ($O_3 + NO_2$, - usually infiltrating)	
External concentration (µg m^{-3})	30.400
Internal concentration (µg m^{-3})	5.300
Pollutant gas 2 (Acetic + formic acid, - mainly inside emission)	
External concentration (µg m^{-3})	33.144
Internal concentration (µg m^{-3})	317.111
Design evaluation	
New volume addition (include minus = "-" if negativ)	0.000
New changed volume	0.315
Added area of total absorber (e.g. activated carbon) (m^2)	0.000
Absorber multiple of internal frame depostion velocity	10
Air exchange interval (d-1)	0.1
Result (SUM - Gas 1+2) (µg $m^{-2}d^{-1}$)	123

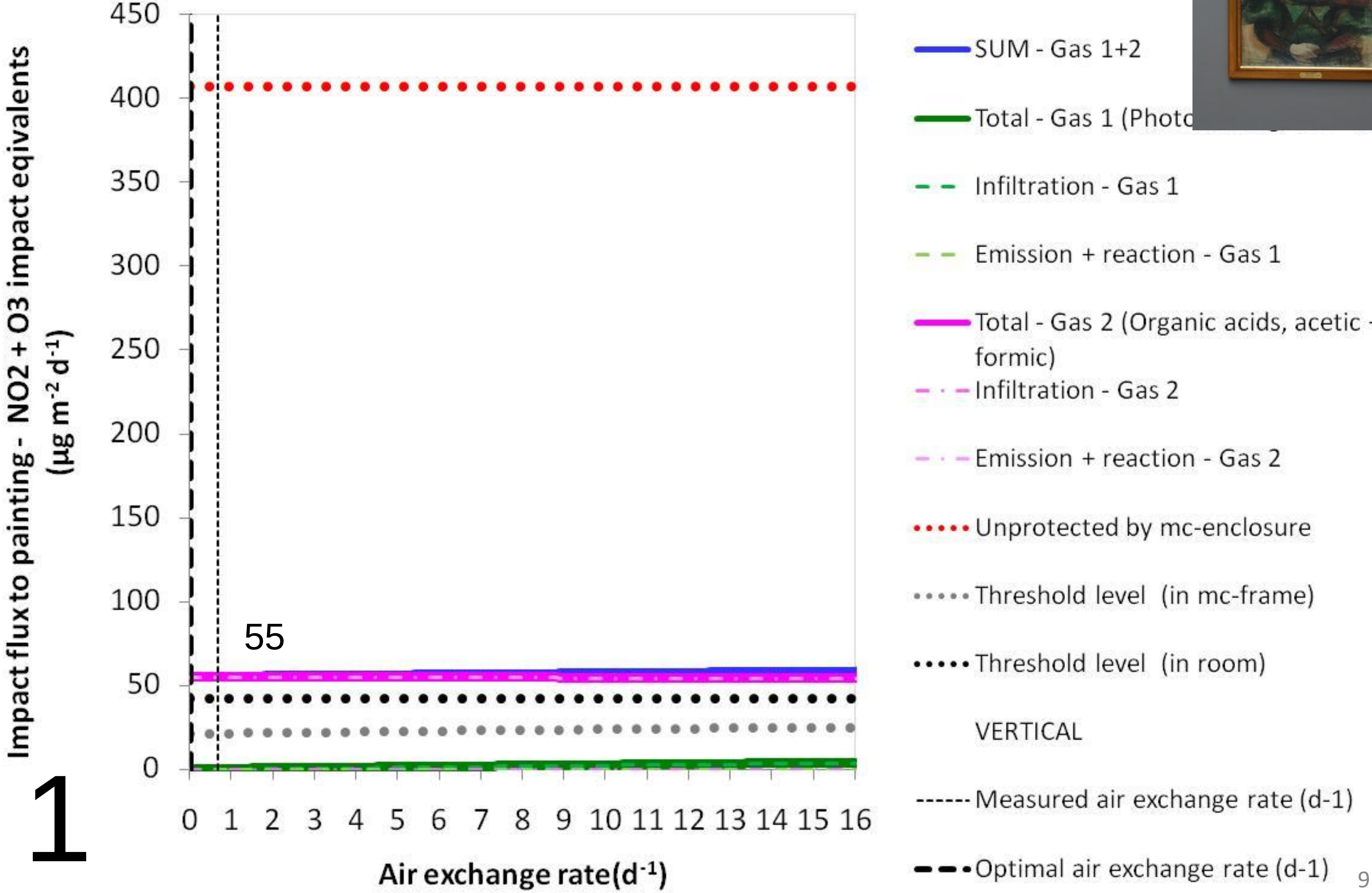
SIXTH FRAMEWORK PROGRAMME

PRO PAIN

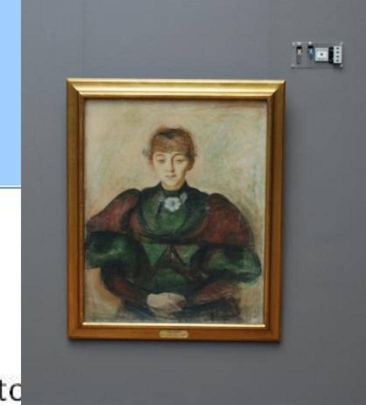
Frame - data

INPUT	Frame and environment data		
Frame geometry	**Frame no 1 (NG)**	**Frame no 2 (KH)**	**Frame no 3 (NMK)**
Volume (m^3)	**0.013**	**0.041**	**0.32**
Internal frame area (m^2)	**0.71**	**1.13**	**1.48**
Object area (m^2)	**1.3**	**1.8**	**0.62**
Air exchange rate (d^{-1})	**0.67**	**1.4**	**14.9**
Pollutant gas 1 ($O_3 + NO_2$) - Usually infiltrating			
External concentration (µg m^{-3})	**38**	**30**	**30**
Internal concentration (µg m^{-3})	**1.5**	**2.5**	**5.3**
Pollutant gas 2 (Acetic + formic acid) - Mainly inside emission			
External concentration (µg m^{-3})	**29**	**63**	**33**
Internal concentration (µg m^{-3})	**260**	**2058**	**317**

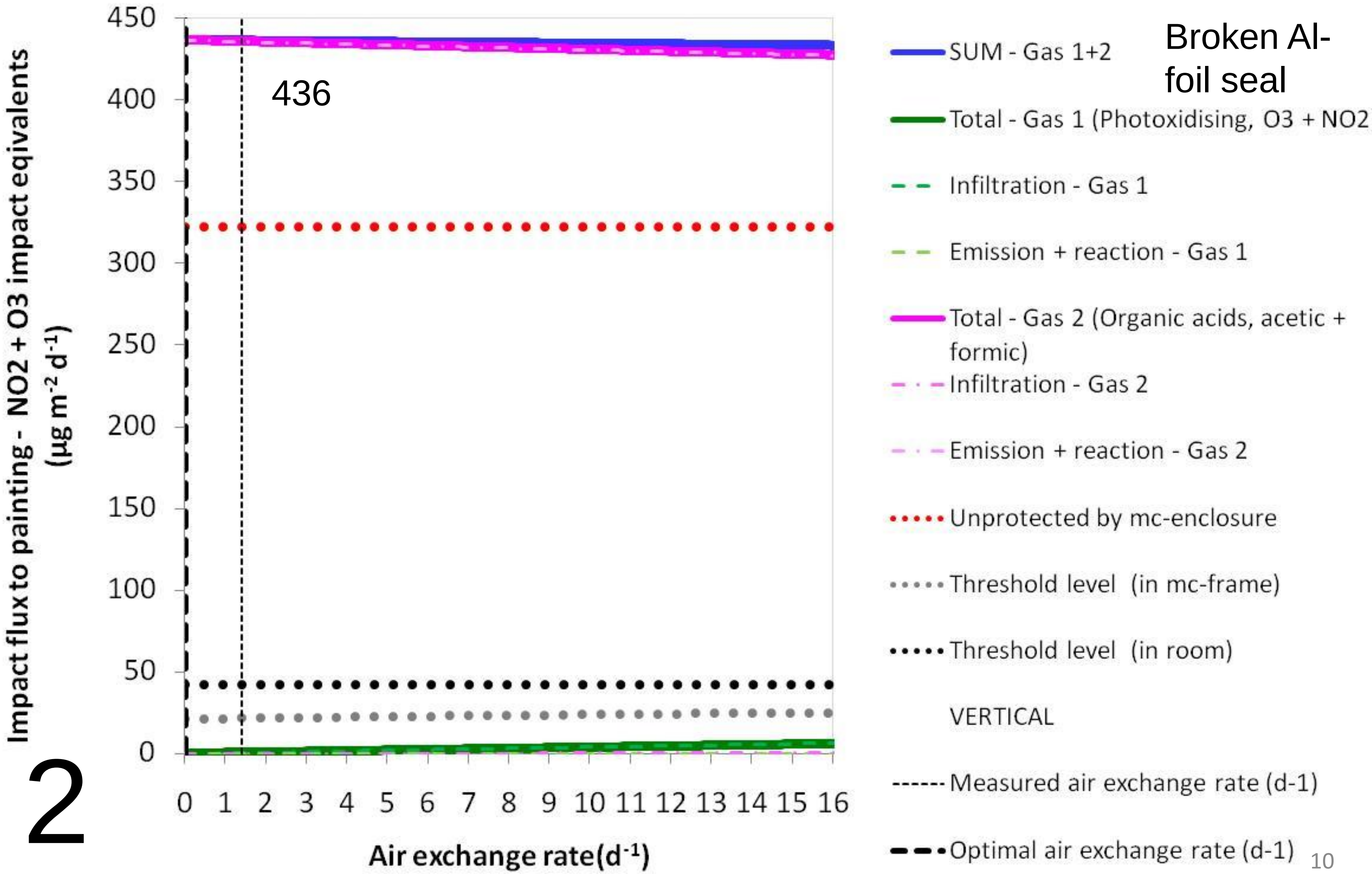
National Gallery – Oslo (Munch)



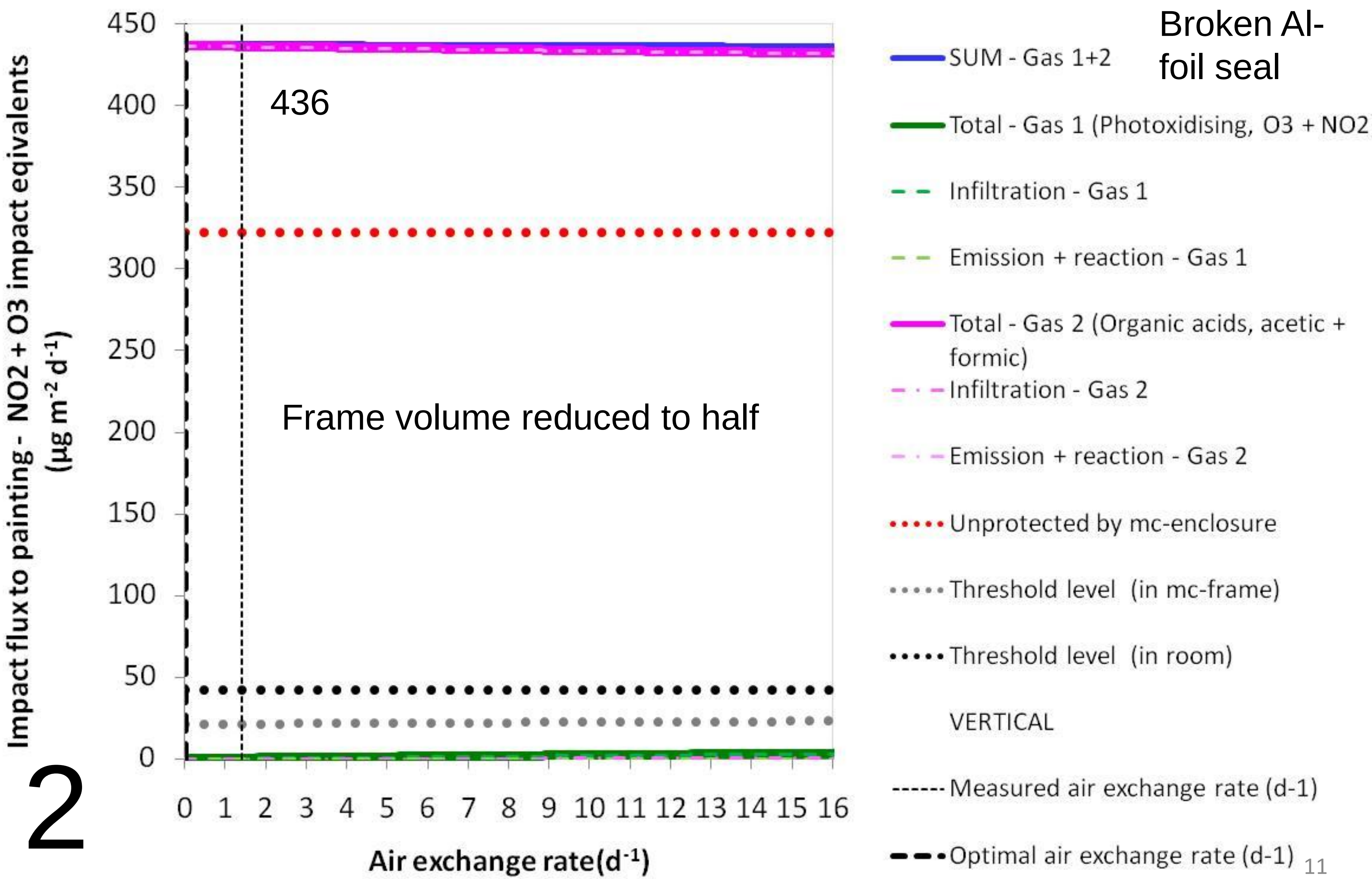
1



Kenwood House – UK (Claude de Jongh)

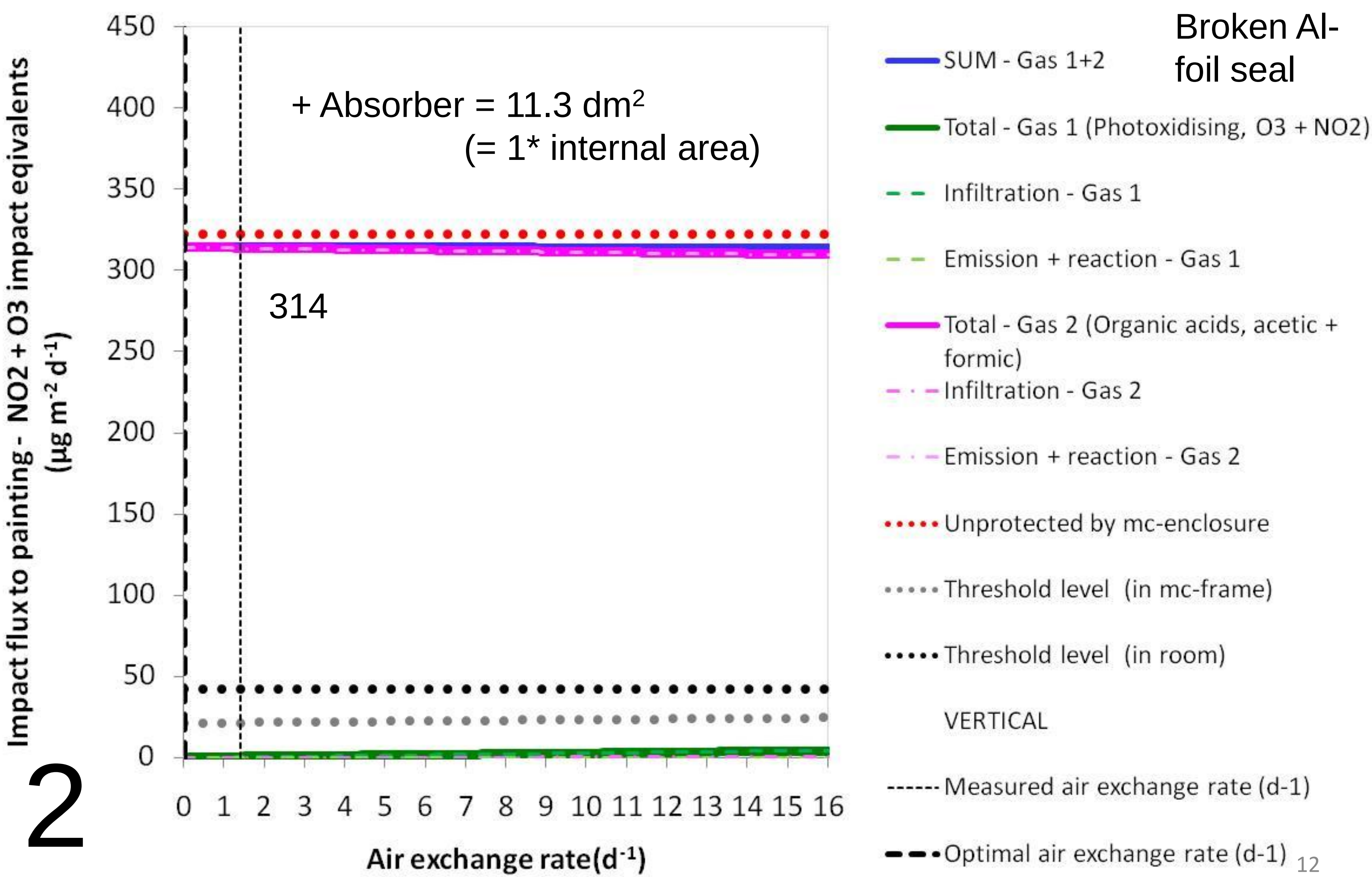


Kenwood House – UK (Claude de Jongh)

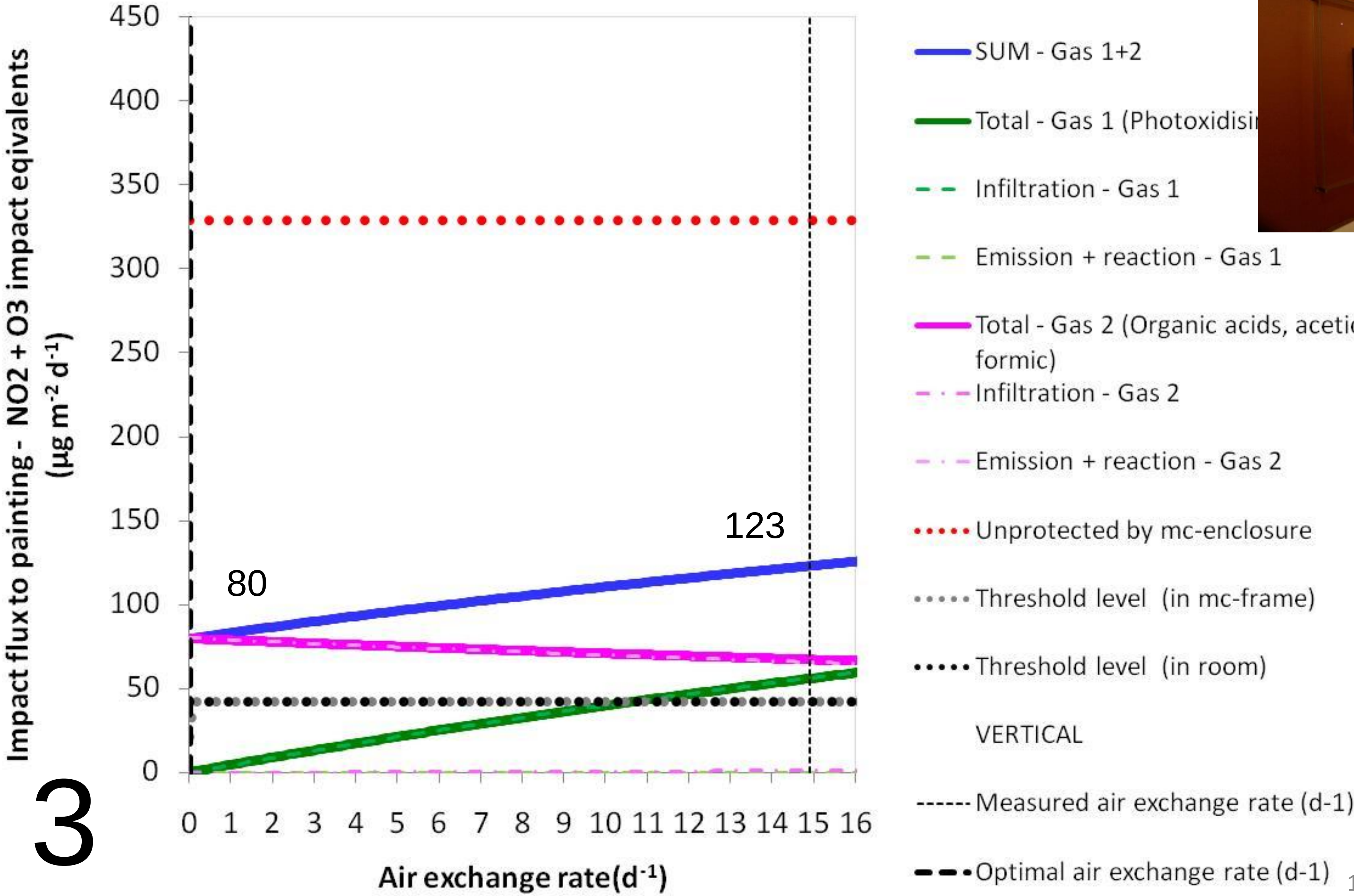


2

Kenwood House – UK (Claude de Jongh)

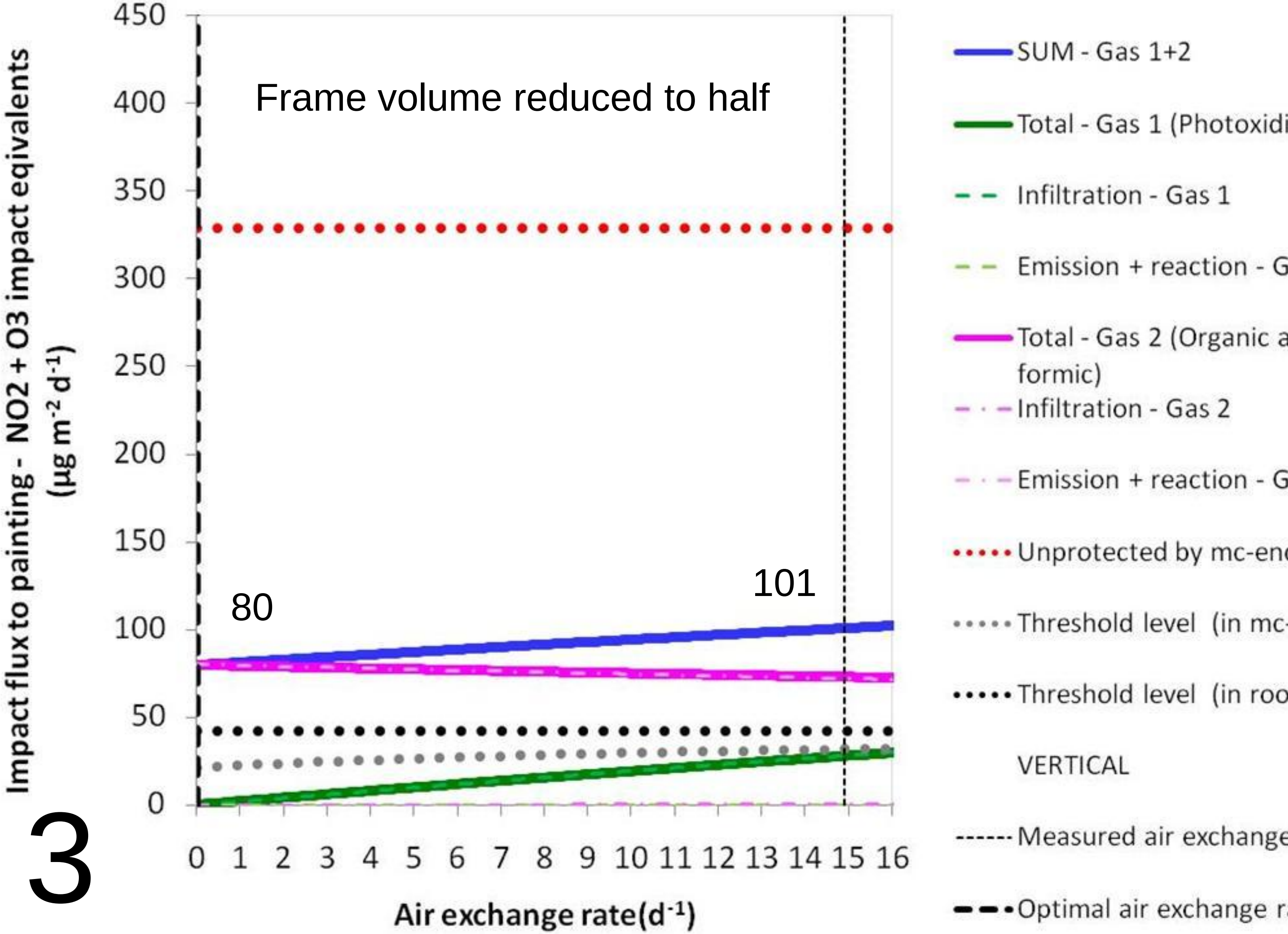


Czartoryski Museum, Krakow (Leonardo)



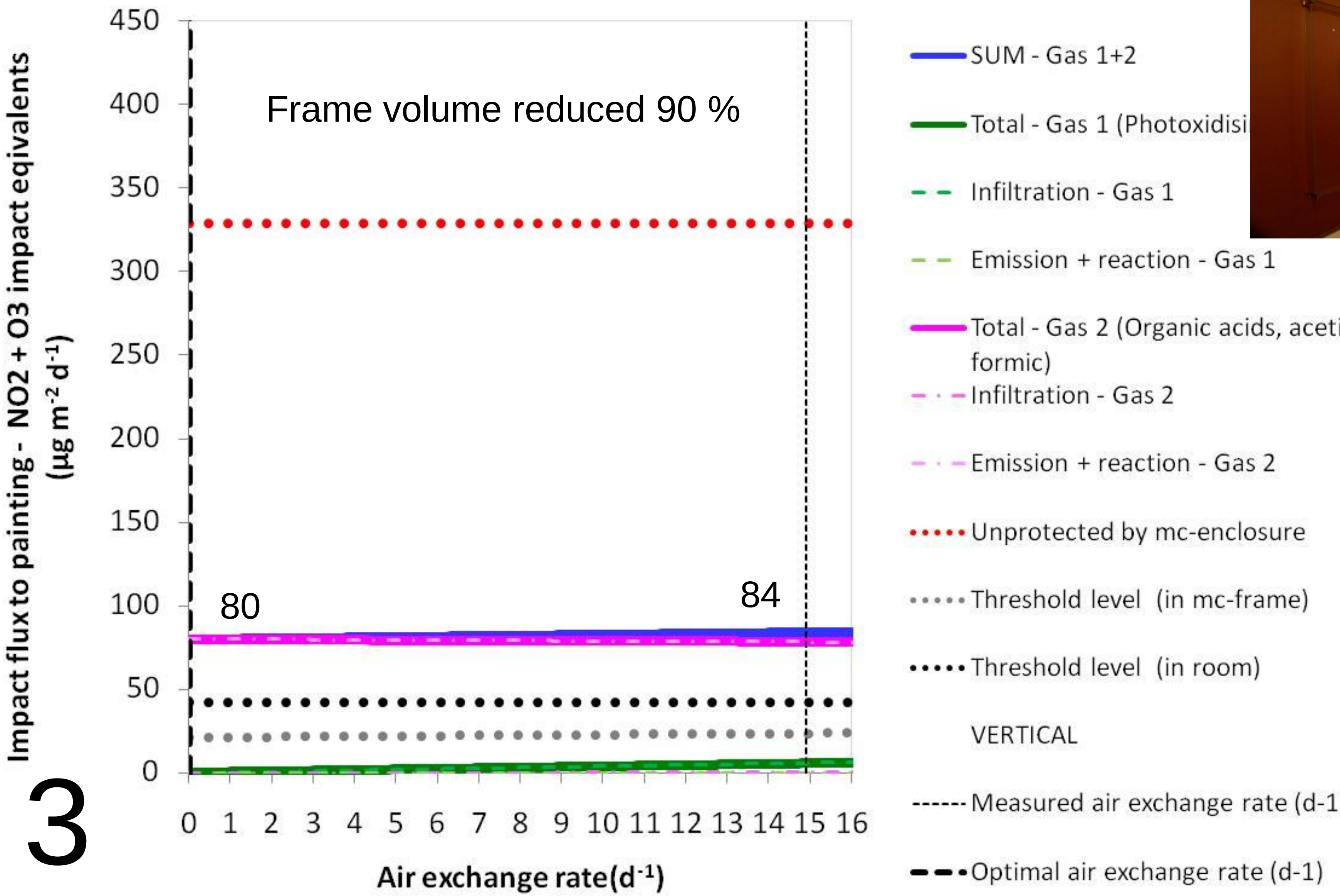
3

Czartoryski Museum, Krakow (Leonardo)

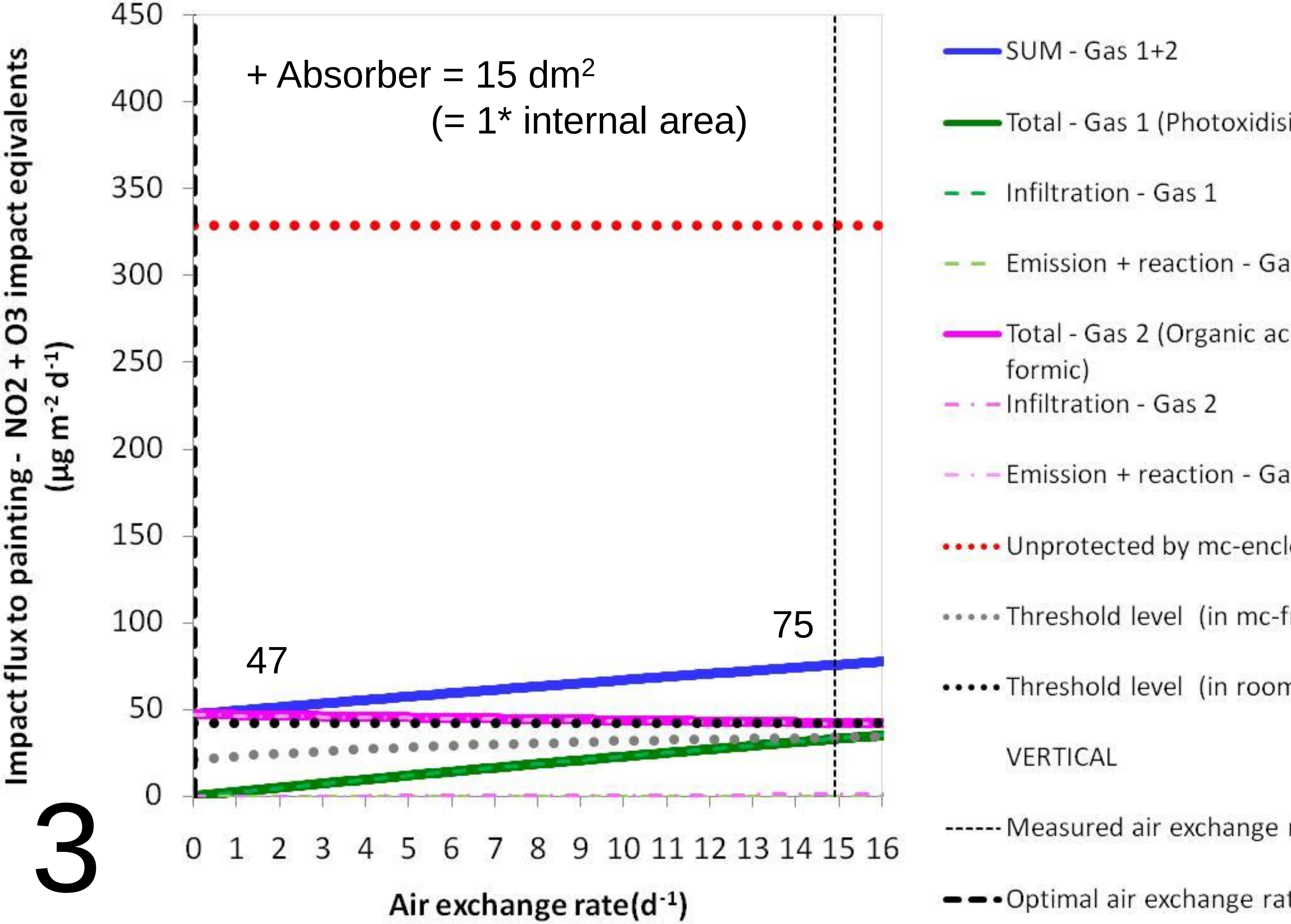


3

Czartoryski Museum, Krakow (Leonardo)



Czartoryski Museum, Krakow (Leonardo)



3

Modelling - Results

Munch | Claude de Jongh | Leonardo

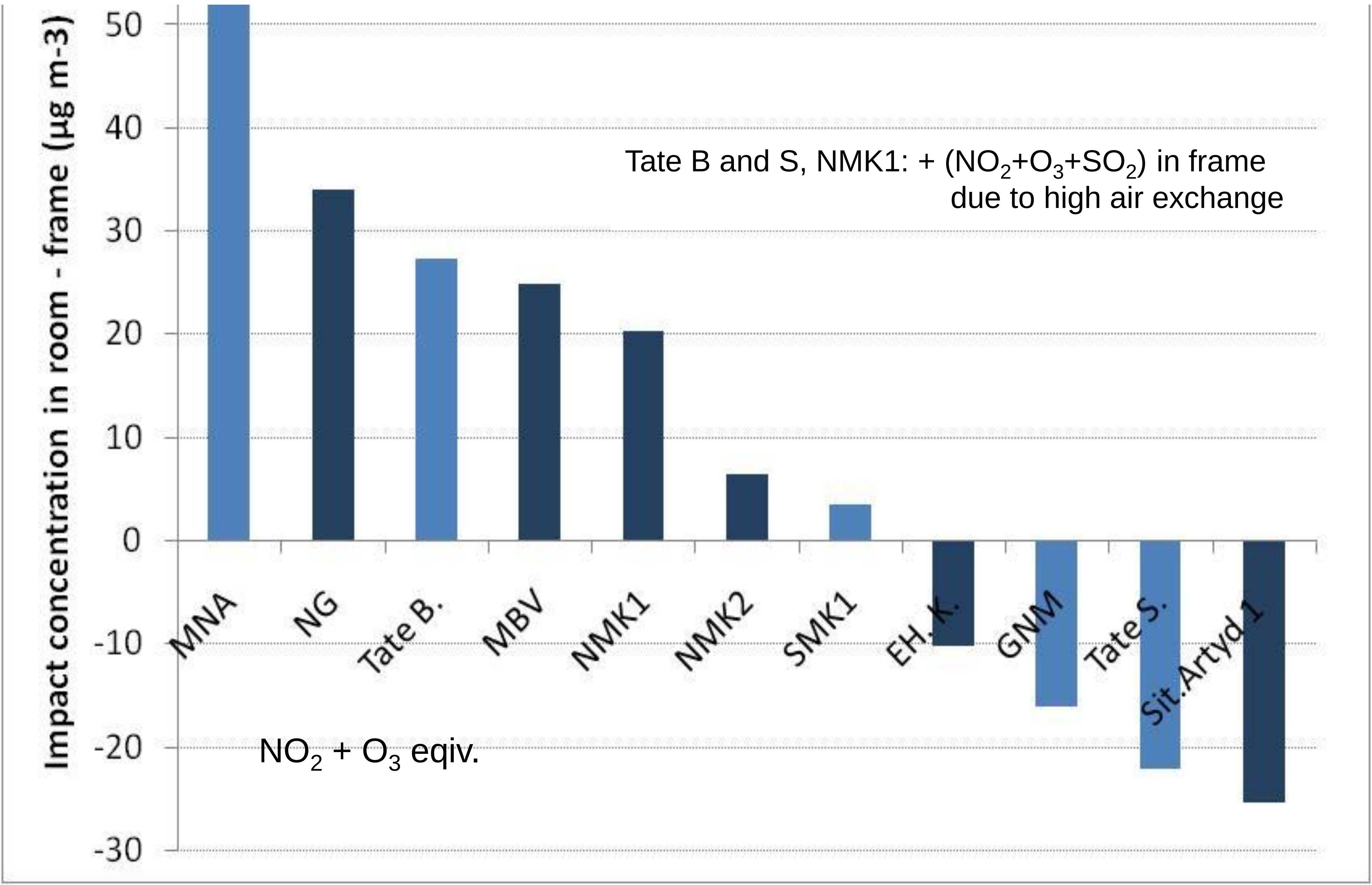
Frame no. (Table 1)	1	2	3	4	5	6
Pollution and frame parameters						
Total impact flux in mc-frame ($\mu g\ m^{-2} day^{-1}$) [1]	584	55	436	125	123	108
Total impact flux in room ($\mu g\ m^{-2} day^{-1}$) [1]	298	407	322	378	329	165
Total threshold impact flux ($\mu g\ m^{-2} day^{-1}$) [1]	22	21	22	21	42	22
Flux from infiltration."Gas 1" ($\mu g\ m^{-2} day^{-1}$)	0.18	0.16	0.53	0.065	56	0.093
Flux from inside emission."Gas 1" ($\mu g\ m^{-2} day^{-1}$)	0	0	0	0	0	0
Total inside emission (+ reaction) rate."Gas 1" ($\mu g\ day^{-1}$)[2]						
Impact flux from infiltration."Gas 2"($\mu g\ m^{-2} day^{-1}$) [1]	0.036	0.0024	0.023	0.0021	1.2	0.028
Impact flux from emission."Gas 2"($\mu g\ m^{-2} day^{-1}$) [1]	584	55	436	125	66	108
Real flux from infiltration."Gas 2"($\mu g\ m^{-2} day^{-1}$)	1.8	0.12	1.1	0.11	61	1.4
Real flux from inside emission."Gas 2"($\mu g\ m^{-2} day^{-1}$) [2]	29200	2747	21800	6250	3300	5420
Total inside emission (+ reaction) rate "Gas 2" ($\mu g\ day^{-1}$)[3]	54300	5480	63300	13200	8380	16900
Surface deposition velocity used, object and frame inside ($m\ s^{-1}$)[4]	0.00012	0.00012	0.00012	0.00012	0.00012	0.00012
Threshold concentration level - "Gas 1" ($\mu g\ m^{-3}$)[5]	2	2	2	2	2	2
Threshold concentration level - "Gas 2" ($\mu g\ m^{-3}$)[5]	100	100	100	100	100	100
"Gas 2" – ventilation for threshold concentration below ($\mu g\ m^{-3}$)	**226**	**13**	**150**	**34**	**23**	**59**
"Gas 2" – threshold concentration, flux = unprotected flux ($\mu g\ m^{-3}$)	**216**	**12**	**137**	**31**	**23**	**55**
"Gas 2" – threshold concentration, flux = threshold flux ($\mu g\ m^{-3}$)	**2736**	**259**	**2070**	**591**	**imp**	**505**
Measured ventilation rate (day^{-1})	0.19	0.67	1.39	0.15	14.9	0.42
Optimal (advised) ventilation rate. (day^{-1})	ventilate	0	ventilate	0	0	0

Modelling - Results

		Munch	Claude de Jongh		Leonardo	
Frame no.	**1**	**2**	**3**	**4**	**5**	**6**
NO_2 + O_3 ($\mu g\ m^{-2}\ d^{-1}$)	0.18	0.16	0.53	0.065	**56**	0.093
(2/100)*(Acetic + Formic acid) ($\mu g\ m^{-2}\ d^{-1}$)	584	55	**436**	125	66	108
Threshold (Ac + Fo) = Unprotected ($\mu g\ m^{-3}$)	216	12	137	31	23	55
Ventilate (V) or Seal (S)	V (?)	S	V (?)	S	S	S

Protection effect of frames vs. rooms

(gaseous pollutants)



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Services for Cultural Heritage Professionals:

http://products.nilu.no

NILU PRODUCTS

Enter Title

NILU Products AS to display newest services at the upcoming UK Museums Association show from October 6th to the 8th in Liverpool, UK. http://www.museumsassociation.org/

Come by and see us in booth 35!

Articles

Phase I

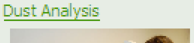
The first phase is to utilize the EWO Dosimeter developed by NILU. The dosimeter reacts in a generic way to the air envronment and detects unfavourable conditions ***before*** noticeable changes on museum objects can be observed. The dosimeter response gives a direct measure for the acceptability of an environment in various areas from archives to exhibitions. The dosimeter is sensitive to **NO_2, O_3, temperature, relative humidity and UV-light** and to high concentrations of SO_2(> 60 ppb). Read More...

Phase II

If Phase 2 is required then we suggest the use of passive samplers to determine the exact cause of the concern. These passive samplers are placed in the same location as the EWO and remain there for one month before being returned to NILU Products for evaluation.

The sample image to the right was created by SVOUM Ltd. to show results of a passive sampler study.
Read More...

Dust Analysis



In addition, NILU Products can also provide dust testing capabilities

Associated pages

- Indoor Analysis Home
- Phase I
- Phase II
- Dust Analysis

FAQs

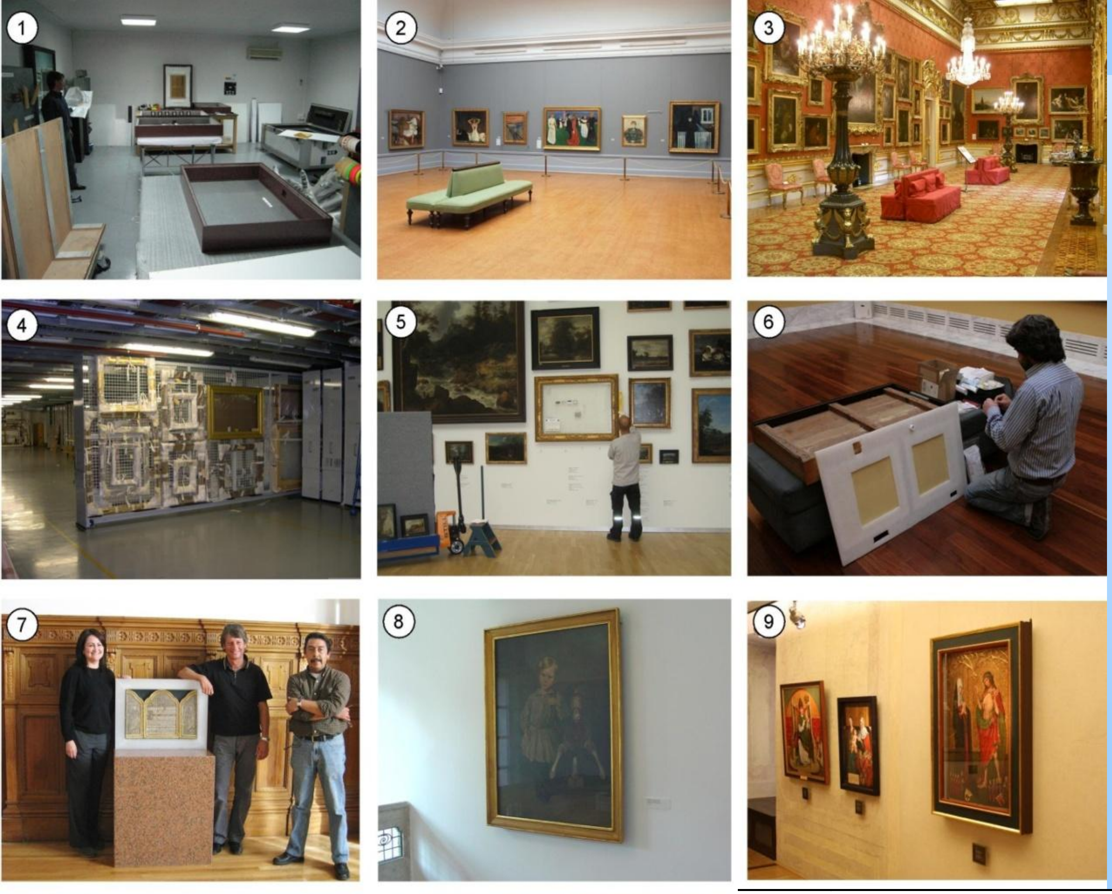
Q. *How does the EWO work?*

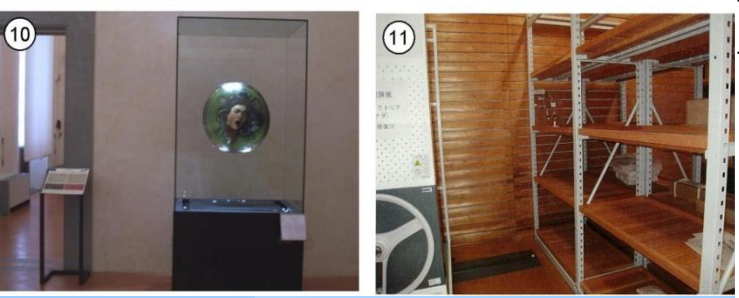
Q. *How often should we perform these tests?*

Q. *How are the results provided?*

Q. *If my results from the EWO Dosimeter are not acceptable then what?*

Q. *What instruments are*





PROPAINT end users:

No	Institution
1	SIT - laboratories
2	Nasjonalmuseet for Kunst, Arkitektur and Design, Oslo, Norway
3	English Heritage, Apsley Hous, UK
4	Tate Store, London, UK
5	Statens Museum for Kunst, Copenhagen, Denmark
6	Fine Arts Museum, Valencia
7	National Museum of Art, Mexico City, Mexico
8	Germanishes Nationalmuseum, Nürnberg, Germany
9	National Museum in Krakow, Poland
10	Uffizi Gallery
11	Centre for Conservation Science and Restoration Techniques, National Research Institute of Cultural Properties, Tokyo

SIXTH FRAMEWORK PROGRAMME

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Thank you!

PROPAINT

NILU - Norwegian Institute for Air Research

BIRKBECK College, Department of Chemistry, University of London

Royal Danish Academy of Fine Arts, The School of Conservation

SIT – International Transporters, Madrid, Spain

Fraunhofer Institute for Silicate Research, Bronnbach, Germany

National Museum in Krakow, Poland

Department of Chemistry and Industrial Chemistry, University of Pisa, Italy

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